SCIENTIFIC NOTE

Release and Establishment of *Encarsia diaspidicola* (Hymenoptera: Aphelididae) Against White Peach Scale (Hemiptera: Diaspididae) in Papaya

Peter Follett[1], Gabor Neumann[2], Robert Hollingsworth[1], Allison Swedman[1], and **Ross Sibucao[3]**

[1]USDA-ARS, Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center, Hilo, HI.
[2]Department of Ecology, Environment and Evolution, La Trobe University, Bundoora, Melbourne, Victoria 3086, Australia.
[3]Hawaii Papaya Industry Association, 190 Kamehameha Ave., Hilo, HI.
Corresponding author: peter.follett@ars.usda.gov

Abstract. White peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozetti) (Hemiptera: Diaspididae) is a serious economic and quarantine pest of papaya, *Carica papaya* L. The parasitic wasp *Encarsia diaspidicola* (Silvestri) (Hymenoptera: Aphelinidae) was brought from Western Samoa into a quarantine containment facility in Hawaii for evaluation and potential release against white peach scale. *E. diaspidicola* was considered an ideal biological control candidate for release in Hawaii because it is reportedly highly host specific. Host range testing in quarantine with several exotic diaspidids and related taxa, including a native palm scale, indicated that *E. dispidicola* is unlikely to attack non-target species or cause harm to the environment if released for control of white peach scale in Hawaii. The Hawaii Department of Agriculture and USDA APHIS issued permits for its release. Releases of *E. diaspidicola* were made beginning in February 2013 in a papaya field in Kapoho on the Big Island. Yellow sticky trap monitoring suggests that the wasp has established in the area of release. Infested papaya logs are being used to spread the wasp to new areas.

Key words: white peach scale, papaya, biological control, parasitoid

The white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozetti) (Hemiptera: Diaspididae), was collected for the first time in Hawaii in September 1997 on papaya, *Carica papaya* L., and quickly became a serious economic pest. This pest causes plant stress, fruit downgrading and quarantine restrictions on exported papaya fruit (Follett 2000). White peach scale has been the target of several biological control programs worldwide (Collins and Whitcomb 1975, Waterhouse and Norris, 1987, Liebregts et al. 1989). *Encarsia berlesei* Howard and *Encarsia diaspidicola* (Silvestri) (Hymenoptera: Aphelinidae) were released in Western Samoa as biological control agents to control white peach scale on passion fruit, *Passiflora edulis* L. Over time, *E. diaspidicola* displaced *E. berlesei* in Samoa and lowered white peach scale population numbers significantly (Liebregts et al. 1989). Because of its successful establishment and control of white peach scale populations

in Samoa, which has a similar climate to Hawaii, *E. diaspidicola* was selected as the preferred biological control agent. In 2006, white peach scale-infested passion fruit vines were imported from Samoa into the USDA Forestry Service Quarantine Facility in Hawaii Volcanoes National Park, and emerging wasps were identified as *Encarsia diaspidicola*.

Host testing

Encarsia diaspidicola is a thelytokous solitary endoparasitoid that deposits eggs in immature stages of white peach scale, with a developmental time to adult of approximately 30-35 days at 23°C (Neumann et al. 2010). Pre-introductory host specificity tests were performed with *E. diaspidicola* in quarantine to evaluate the potential for non-target effects (Neumann et al. 2010). False oleander scale, *Pseudaulacaspis cockerelli* Cooley (Diaspididae), coconut scale, *Aspidiotus destructor* Signoret (Diaspididae), cycad scale, *Aulacaspis yasumatsui* Takagi (Diaspididae), greenhouse whitefly, *Trialeurodes vaporariorum* Westwood (Aleyrodidae), green scale, *Coccus viridis* Green (Coccidae), and long-tailed mealybug, *Pseudococcus longispinus* Targioni-Tozzetti (Pseudococcidae) were tested using traditional no-choice tests and examined for wasp emergence. The Hawaiian endemic palm scale, *Colobopyga pritchardiae* (Stickney) (Halimococcidae) was also tested using no-choice tests and evaluated using species-specific molecular markers (Neumann et al. 2010, de Leon et al. 2010). Halimococcids were at one time classified as diaspidids (Neumann et al. 2007). All tests used unexposed non-target cohorts and no-choice exposure of white peach scale to the parasitoid as controls. None of the non-target exotic species yielded wasp emergence, and exposure to wasps had no effect on the mortality of the non-target species examined. Wasps consistently emerged from white peach scale controls. Molecular tests with the endemic palm scale showed no evidence of parasitism by *E. diaspidicola* (de Leon et al. 2010). These results strongly supported that *E. diaspidicola* has a narrow host range and that its release in Hawaii should have negligible risk of non-target effects (USDA APHIS 2011). Based on this evidence that *Encarsia diaspidicola* will not attack non-target species, the Hawaii Department of Agriculture and USDA APHIS issued permits for its release.

Field release

The first release of *E. diaspidicola* was made in February 2013 on an 8-acre commercial papaya field farmed by Ross Sibucao in Kapoho on the Big Island. This field mainly contained 'Rainbow' papayas and was surrounded by other similar papaya fields. Papaya trees were healthy and bearing fruit during the period that releases were made. White peach scale infestation of papaya trees at the release site was patchy, but most trees had at a light infestation on the trunk and approximately one in ten trees was heavily infested. Insecticide and fungicide sprays were mainly directed at the foliage and fruit and not the tree trunks where most of the white peach scales resided.

Butternut squash, *Cucurbita moschata* Duchesne ex Lam. was the laboratory rearing host for white peach scale and *E. diaspidicola* throughout the project (Neumann et al. 2010). An infested squash with parasitized scales was placed in each of three elevated covered trays that were enclosed in bird netting for three weeks in the papaya field to allow for parasitoid emergence. The rate of parasitism of scales on the release squashes was not determined and all three available host squashes were used for the release, but based on previous rearing data, perhaps 100-200 wasps may have emerged from

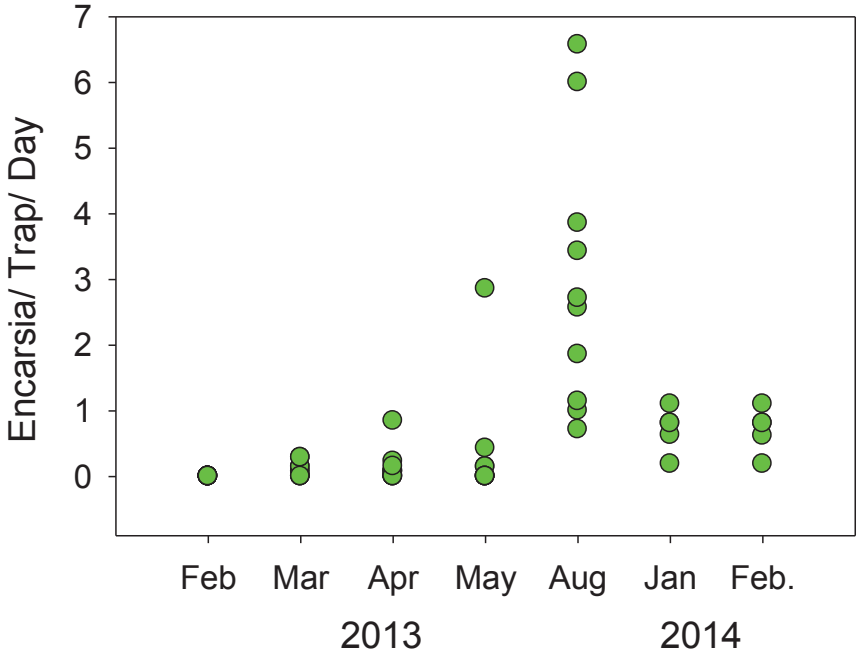

Figure 1. Number of *E. diaspidicola* caught in individual yellow sticky traps in the Sibucao papaya field (Kapoho, Hawaii). The first releases were made in February 2013.

the scale-infested squashes. Yellow sticky traps (Alpha Scents, 18 x 14 cm) were used to determine establishment and population trends. *E. diaspidicola* is distinctive and easily separated from other parasitic Hymenoptera captured by the traps. Eight to ten traps were attached at approximately 1.5 m height on papaya trunks along a transect down the middle of the field (1 trap every 10 rows) for 1 to 2 weeks, then removed and inspected in the laboratory under a stereomicroscope for any *E. diaspidicola* wasps. Traps were placed at irregular intervals between February 2013 and February 2014. *E. dispidicola* was collected on all trapping dates after the initial release (Fig. 1). The number of trap catches increased during the first 6 months after release, possibly due to increased parasitism and growth of the *E. diaspidicola* population. Lower numbers on the last two collections dates in early 2014 may have been due to the age of the papaya field as harvesting had ended and trees were falling down or in declining health, or to cooler temperatures.

By September 2014, the release field had rampant weeds but a small number of old trees were still standing. Ten trees were identified that had moderately high densities of white peach scale females. These trees were cut up into 50 cm sections with a chainsaw on September 18, 2014 and brought to the Hawaii Papaya Industry Association annual meeting the next day. Three or four papaya logs were distributed to each of 15 papaya growers from East Hawaii after the meeting. Our recommendation was to place the logs a minimum 5 m outside their papaya field, but near

white peach scale-infested trees, so that emerging wasps could locate hosts while minimizing the chance that any crawler stage white peach scales might infest the nearest trees. Three infested papaya logs were held individually in the laboratory in ventilated plastic boxes (50 x 36 x 14 cm) lined with yellow sticky traps to estimate the number of female white peach scales (all settled life stages), rates of parasitism (visual count of exit holes), and emergence of live *E. diaspidicola* wasps. The three papaya logs had approximately 800, 1350 and 1450 scales, with parasitism rates of 5.0, 11.9 and 6.2%, respectively, and after four weeks a total of 8 live wasps were recovered from yellow sticky traps placed inside the emergence boxes. This suggests that the papaya logs distributed to papaya farmers harbored only a small number of live *E. diaspidicola*. *E. diaspidicola* is established in the Kapoho area of lower Puna on the Big Island, but additional distributions of infested papaya logs from fields shown to have *E. diaspidicola* parasitized scales will be made in the future to facilitate the spread of this biological control agent. Studies are still needed to determine the effects of *E. diaspidicola* parasitism on white peach scale population dynamics and crop loss.

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